UTAH GEOLOGICAL SURVEY

SURVEY NOTES

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Bryce Canyon National Park

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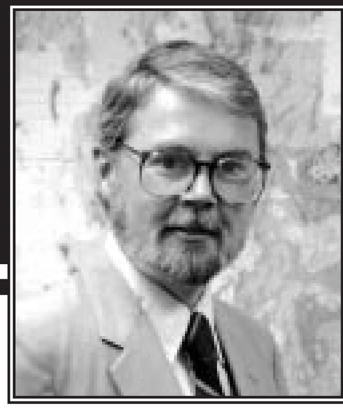


The Director's Perspective

by M. Lee Allison

Across the country, geological surveys are evolving; in part to respond to outside demands, in part to take advantage of new opportunities. In recent years, some of those surveys that did not change with the times faced drastic budget cuts or outright elimination. Even the venerable U.S. Geological Survey was on one congressional hit list.

The Utah Geological Survey historically has been fortunate in receiving strong, but generally benign, support from the state's legislature. In order to ensure that the UGS continues to anticipate and respond to the state's needs, we are making some changes.

We recently reorganized part of our scientific team. The Water Section of the Applied Geology Program was transferred into the Paleontology & Paleoecology Program, which was subsequently renamed the Environmental Sciences Program (ESP). Mike Lowe, who had been running the Water Section, was named Acting Program Manager for the new group. Dr. David Madsen, will serve as Senior Scientist, advising Mike, and as Chief of the Paleoecology Section. Dr. David Gillette was formally designated State Paleontologist and will be Chief of the Paleontology Section. Mike Lowe will also oversee the Water Section.

Environmental Sciences becomes the second-largest program in the UGS, behind Economic Geology. It is also the most diverse, having geologists, archeologists, paleontologists and others. This diversity is intended to help us better tackle the complex multi-disciplinary challenges affecting society.
Some of the issues the ESP is taking on include integrating the geology and hydrology of groundwater basins, establishing an evolutionary framework or baseline to ecosystem studies, detailing long-term patterns of regional climate change, and increasing dinosaur research, preservation, and tourism.

The U.S. Geological Survey is pursuing a similar diversification. Dr. Gordon Eaton, director of the USGS, recently told a small group of us that geology now accounts for only about one-sixth of the total USGS budget. With the incorporation of the National Biological Service as the Biological Resources Division, and scientists and engineers from the former U.S. Bureau of Mines, the USGS is moving towards becoming a "natural resources science agency", perhaps within the next five years.

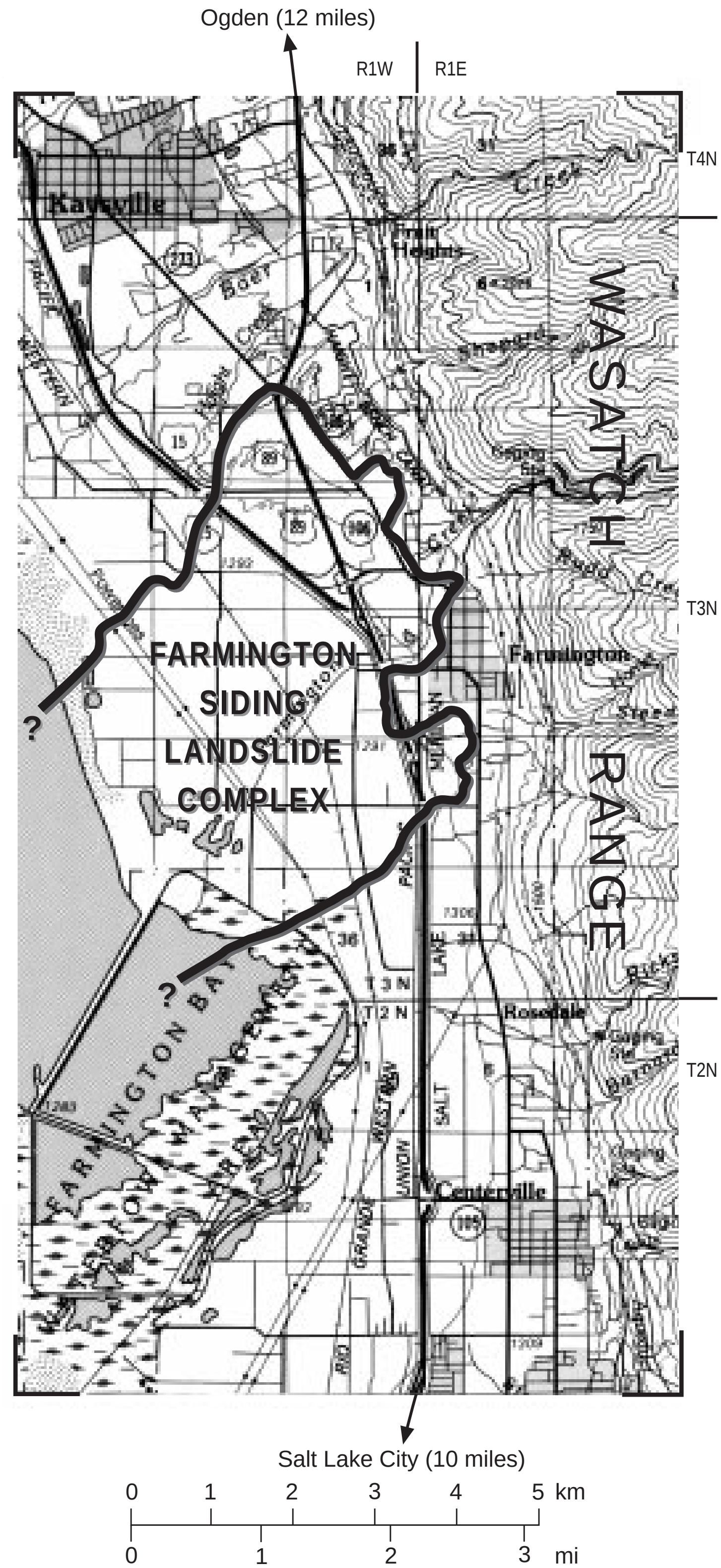
While Dr. Eaton sees geology as a diminishing force at the USGS as a result of their broader role, we see geology continuing in its central role at the UGS. Our emphasis will be on integrating the other natural-resource activities with the traditional geology work we have always done. Our goal will be to be more effective in addressing complex scientific issues, disseminating the information we generate or gather, affecting public and private policies, and helping ensure that appropriate technical information is incorporated into whatever solutions are implemented. In other words, we want the geologic work we do to make life better for the people that pay our way, the citizens of Utah.

In my next column I will explain in more detail our increased emphasis on information dissemination and the use of that information on implementation of public and business policy.

Survey Notes is published three times yearly by Utah Geological Survey, 1594 W. North Temple, Suite 3110, Salt Lake City, Utah 84116; (801) 537-3300. The UGS inventories the geologic resources of the state, identifies its geologic hazards, disseminates information concerning Utah's geology, and advises policymakers on geologic issues. The UGS is a division of the Department of Natural Resources. Single copies of *Survey Notes* are distributed free of charge to residents within the United States and Canada.

Hazard Assessment of the Farmington Siding Landslide Complex, Davis County, Utah

by Michael D. Hylland



Location of the Farmington Siding landslide complex. Base map from USGS 1:100,000 series.

The prehistoric Farmington Siding landslide complex (FSLC) covers an area of about 7.5 square miles in Utah's rapidly growing Wasatch Front, and it contains some of the largest landslides triggered by earthquakes in the United States. In a project run by the Utah Geological Survey (UGS) with partial funding from the U.S. Geological Survey (USGS) National Earthquake Hazards Reduction Program, we mapped the landslide deposits and excavated trenches within the FSLC to investigate the types of landsliding that occurred and obtain organic-rich sediment samples for radiocarbon analyses to determine the timing of landslide events. The mapping and trench data, radiocarbon ages, other soil and ground-water data, and information on prehistoric climates and earthquakes were used to assess the hazard associated with future landsliding within and near the FSLC.

Landsliding in the FSLC involved unconsolidated silt and sand deposits of Great Salt Lake and ancient Lake Bonneville, and resulted from liquefaction of these deposits. Liquefaction occurs when strong earthquake ground shaking causes saturated, sandy soils to lose strength and behave like a liquid. This can cause overlying soil layers to slide or flow downslope, even on very gentle slopes. Evidence for liquefaction at the FSLC includes upward injection of sand into overlying silty deposits and failure of very gentle slopes (0.6 to 6 degrees) that otherwise are not susceptible to landsliding.

Trench exposure of Lake Bonneville deposits showing liquefied sand (arrow) injected upward into thin, flat-lying silt beds. Trowel shown for scale.

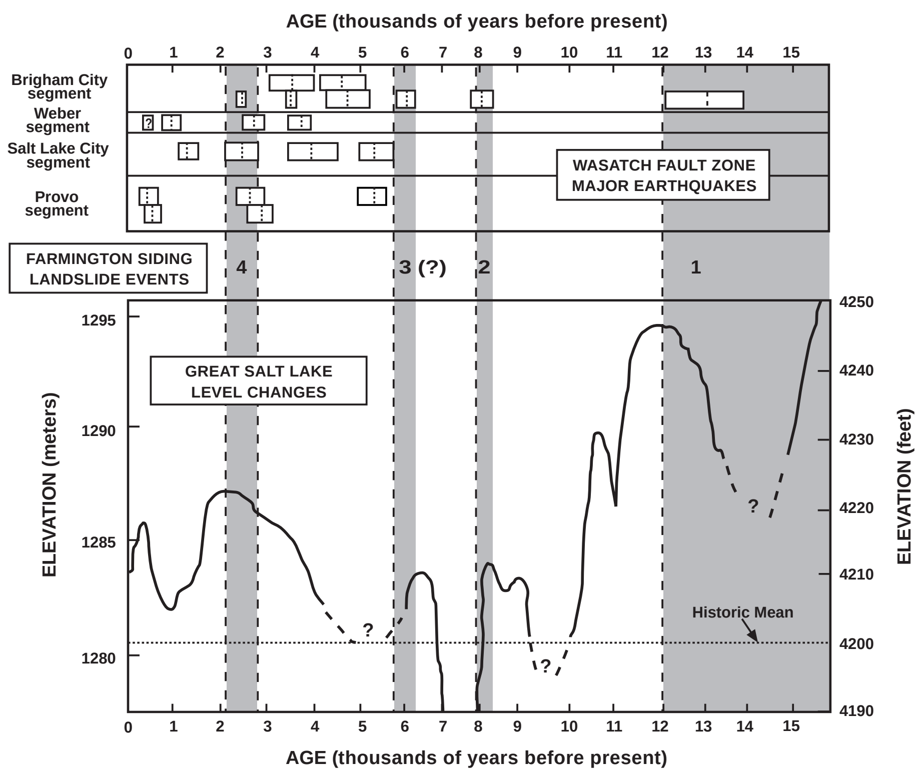
The FSLC shows evidence of recurrent landsliding during about the past 16,000 years. Based on soil radiocarbon ages and cross-cutting relations of ancient lake shorelines, at least three, and possibly four, episodes of landsliding have occurred in different parts of the FSLC. The first was sometime before 12,000 years ago, the second just prior to 8,100 years ago, the third(?) sometime prior to 6,000 years ago, and the fourth between 2,750 and 2,150 years ago. Landslide events correspond well with Great Salt Lake highstands and associated high ground-water levels, as well as with the timing of large earthquakes on nearby segments of the Wasatch fault zone.

The Weber segment of the Wasatch fault zone is the nearest mapped fault to the FSLC, and several independent lines of evidence indicate that large (surface-faulting) earthquakes on this fault are the most likely to trigger significant liquefaction-induced landsliding at the FSLC. Geologists believe that five or six large earthquakes have occurred on the Weber segment during the past 16,000 years, but fault studies have been able to expose geologic evidence for only the three most recent earthquakes which have occurred since about 4,000 years ago. The timing of landsliding within the FSLC, therefore, provides indirect evidence for the approximate timing of large earthquakes on the Weber segment that predate the earthquakes documented in fault studies.

The potential for reactivated landsliding within the FSLC may currently be less than at other times during the recent geologic past, given the relatively lower lake and ground-water levels that exist today. However, some areas within and near the FSLC may be more prone to landsliding than others because of local "perched" ground-water levels. The best chance for liquefaction-induced landsliding exists when lake and / or ground-water levels are high, such as during the historic highstands of Great Salt Lake in 1873 and 1986-1987, and the area experiences strong earthquake ground shaking. The relative likelihood of a large earthquake in the vicinity of the FSLC in the near future and the possible consequences of extensive landsliding warrant prudent land-use planning and detailed engineering studies for high-risk development in this area.

REFERENCE

Murchison, S.B., 1989, Fluctuation history of Great Salt Lake, Utah, during the last 13,000 years: Salt Lake City, University of Utah, Ph.D. thesis, 137 p.



Comparison of the timing of landslide events within the FSLC (shaded areas) with major earthquakes on the Wasatch fault zone (top) and fluctuations of Great Salt Lake (bottom). Earthquake chronologies based on work by others; Great Salt Lake levels from Murchison (1989).

The Rockhounder

by Sandy Eldredge

Agate, chert, jasper, and petrified wood between Capitol Reef National Park and Caineville, Wayne County

Geologic information:
Agate, chert, and jasper are varieties of microcrystalline or cryptocrystalline quartz (quartz having crystals that are too small to be detected with a hand lens) that have either a waxy or a dull luster. They can form in different ways; one of the most common is through ground water action by the leaching of highly siliceous rocks, filling rock fractures and cavities, and recrystallizing. Petrified wood is fossil wood in which the organic material has been replaced by cryptocrystalline quartz during the process of fossilization. Much of the delicate structure of the wood is preserved because of the small crystal size.

More than 100 million years ago, the area near Capitol Reef National Park was alternately covered by water from oceans, streams, and lakes in which muds, silts, sands, and mixtures of sediment were deposited. These sediments eventually became mudstones, sandstones, and conglomerates; cavities in these rocks were later filled in with the quartz. Weathering of these rocks has released the agate, chert, and jasper that now are scattered on the terrain. These ornamental rocks are attractive for their colors, shapes, or as mementos of the geologic past.

How to get there:
From Caineville, travel 8.5 miles west on Utah Highway 24 to where the road crests over a pass. At this spot, you can see the towering sandstone monoliths in Capitol Reef National Park several miles to the west.

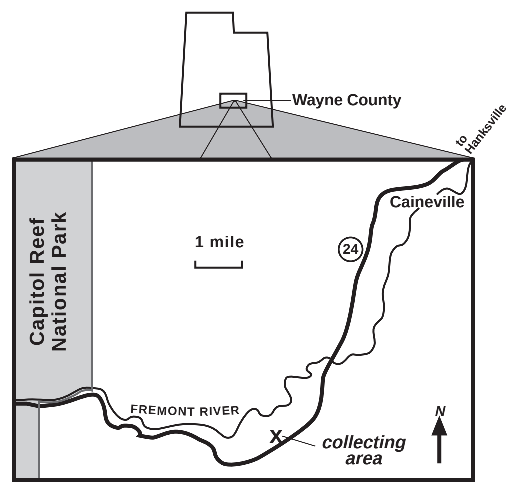
Where to collect:
On the north side of the road, collecting can begin next to the road and continue up the hillslopes. Scattered on the gray- and brown-colored hills are pieces of agate, chert, jasper, and petrified wood, as well as large black boulders deposited by ancient streams. The agate and chert at this location are white, gray, green, purple, orange, and red. The jasper is typically red due to iron content. Many specimens are broken nodules or pebbles. The petrified wood is tan and found in small pieces. Petrified wood is more difficult to find, probably because the larger specimens have already been collected.

Useful maps:

Loa 1:100,000-scale metric topographic map.

Caineville 7.5-minute topographic map.

Land ownership:
Bureau of Land Management (BLM) public lands.



BLM collecting rules:
The casual rockhound or collector may take small amounts of the agate, chert, jasper, and other rocks from unrestricted federal lands in Utah without obtaining a special permit if collection is for personal, non-commercial purposes. Collection in large quantities or for commercial purposes requires a permit, lease, or license from the BLM. Petrified wood may be collected for non-commercial use in quantities up to 25 pounds plus one piece of any size per day, with a yearly limit of 250 pounds.

Miscellaneous:
Easy parking can be found off the road. Specimens can be found within yards of your car, or you can hike up the hills. A hat and hiking shoes are recommended. Have fun collecting!

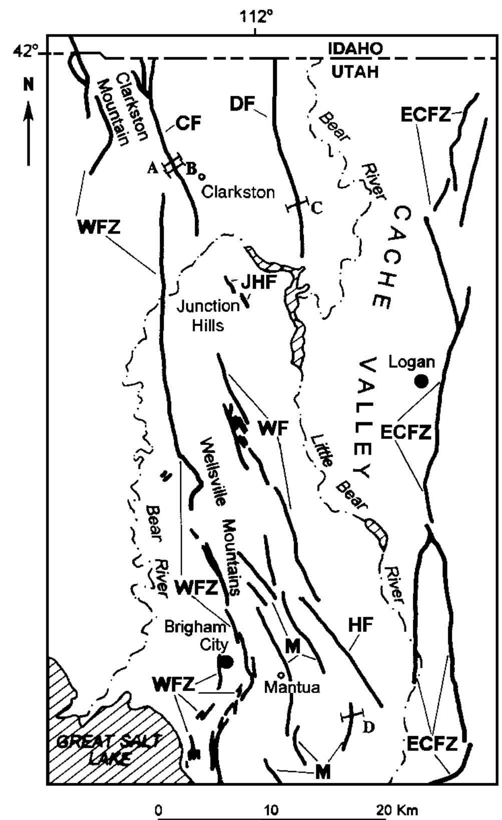
Visit our Rockhounder web page at http://utstdpwww.state.ut.us/~ugs/rockhndr.htm

Mapping the West Cache Fault Zone

by Barry J. Solomon

The West Cache fault zone (WCFZ) extends about 35 miles (56 km) along the west side of Cache Valley in northern Utah and southern Idaho, near the northern Wasatch Front. The WCFZ is between Logan and Brigham City and is one of three fault zones (West Cache, Wasatch, and East Cache) in the vicinity of Cache Valley with evidence of late Quaternary movement (the Quaternary period includes the last 1.6 million years). The Wasatch fault zone bounds the western edge of mountains on the western margin of Cache Valley, is recognized as the most active fault zone in Utah, and is the most likely source of future surface-faulting earthquakes in the region. The East Cache fault zone bounds the eastern edge of Cache Valley and has experienced at least one large-magnitude surface-faulting earthquake during the Holocene (the Holocene epoch includes the last 10,000 years). Detailed trenching studies to identify prehistoric earthquakes have been conducted for both the Wasatch and East Cache fault zones, but not for the WCFZ. I recently mapped the geology of the WCFZ in detail under a grant from the National Earthquake Hazards Reduction Program (NEHRP), administered by the U.S. Geological Survey. This map, scheduled for release by the UGS in 1997, provides valuable information to assess the earthquake potential of the WCFZ, identify future trench sites, and estimate seismic hazard and risk from future large earthquakes in Cache Valley.

The WCFZ includes three faults and three additional areas of faulting that may be extensions of the fault zone. I mapped thirty-three Quaternary unconsolidated units and six older bedrock units to help interpret the geologic history of the WCFZ. The three faults in the WCFZ are, from north to south: (1) the Clarkston fault, a linear range-front fault on the east side of Clarkston Mountain in the southern Malad Range; (2) the Junction Hills fault, a series of short fault traces at the eastern edge of the Junction Hills between Clarkston Mountain and the Wellsville Mountains; and (3) the Wellsville fault, on the eastern edge of the Wellsville Mountains. Faceted spurs (triangular ridge faces formed by faulting) along the linear Clarkston fault suggest possible Holocene movement, but active colluvial (gravity induced) processes and dense vegetation at the base of the spurs have obliterated any evidence. The Junction Hills fault offsets Lake Bonneville deposits about 17,000 to 19,000 years old, but fault movement is apparently no younger. The Wellsville fault is concealed at the mountain front, and its lack of surface expression suggests a similar lack of recent geologic activity. I found no evidence of Holocene activity along the three possible extensions of the WCFZ: (1) the Dayton



Map of Cache Valley with proposed trench locations A, B, C, and D. CF - Clarkston fault, DF - Dayton fault, ECFZ - East Cache fault zone, HF - Hyrum fault, JHF - Junction Hills fault, M - faults in the Mantua area, WF - Wellsville fault, WFZ - Wasatch fault zone.

fault in north-central Cache Valley, (2) the Hyrum fault in Cache Valley south of the Wellsville fault, and (3) several faults near the town of Mantua, in the interior of the Wellsville Mountains and Wasatch Range.

Although this detailed mapping contributes to our understanding of the earthquake hazard posed by the WCFZ and provides basic data necessary to evaluate this and other geologic hazards in the west Cache Valley, questions related to potential earthquake size and timing, fault segmentation, and surface fault rupture remain. These questions may only be resolved by excavating trenches to expose geologic relations obscured by colluvium and dense vegetation, and to collect samples for radiocarbon dating to establish an accurate record of prehistoric surface-faulting earthquakes. The UGS has applied for an additional grant from NEHRP to fund trenching.

Late Holocene alluvial fans cross the linear, range-front Clarkston fault. Part of the West Cache fault zone, the fault is marked by triangular faceted spurs between the canyons.

An earlier publication was released in 1994 on "Neotectonic deformation along the East Cache fault zone" as SS-83. Contact the DNR Bookstore, (801)537-3320.

Harken is first contributor to the UGS Sample Library Trust Fund

by Kimm M. Harty

In November 1996, Harken Southwest Corporation made the first contribution to the newly established UGS Sample Library Trust Fund. The fund was created through legislative approval to provide financial support for continued operations of the UGS Sample Library. The fund's principal will remain intact as the fund grows and only the interest accrued will be used to maintain library functions and purchase equipment. Harken's donation represents the first of what we hope to be many contributions to the fund, and the beginning of long-term financial stability for the facility.

The UGS Sample Library is a public facility designed for preserving and studying geological samples and associated data collected in Utah. Since its establishment in 1951, the collection has grown substantially and has been relocated several times. The Sample Library provides a repository for rock core, cuttings, and other samples that might otherwise be discarded due to industry and government budget constraints and reorganizations. The UGS makes this valuable resource available at minimal charge to industry, university, and government researchers, and to the general public.

With the cost of renting warehouse space sky-rocketing in today's market, the 1995-96 Utah Legislature authorized construction of a state-owned Sample Library building. UGS funds currently used to lease a warehouse will go toward paying off the new building so that we will own it outright in about 25 years. The approximately 12,000-ft^2 building will be at the north end of the Department of Natural Resources campus and will be completed in 1997. The building will be the new home of the UGS Sample Library and will also contain office space, a layout room, and a laboratory for preparing and preserving rock and fossil specimens. Our goal for the new, larger Sample Library is to create a facility that is optimally designed for both storing samples and functioning as a research center.

The Sample Library has been increasingly used for education and research such as core workshops for oil company training sessions, short courses, college thesis work, and sample evaluation / analysis for UGS / industry cooperative projects such as the DOE-funded Bluebell oil field, Ferron Sandstone, and Paradox basin projects. Providing educational and research opportunities will continue to be a primary focus of the new facility, and we intend to increase advertising and marketing of Sample Library services.

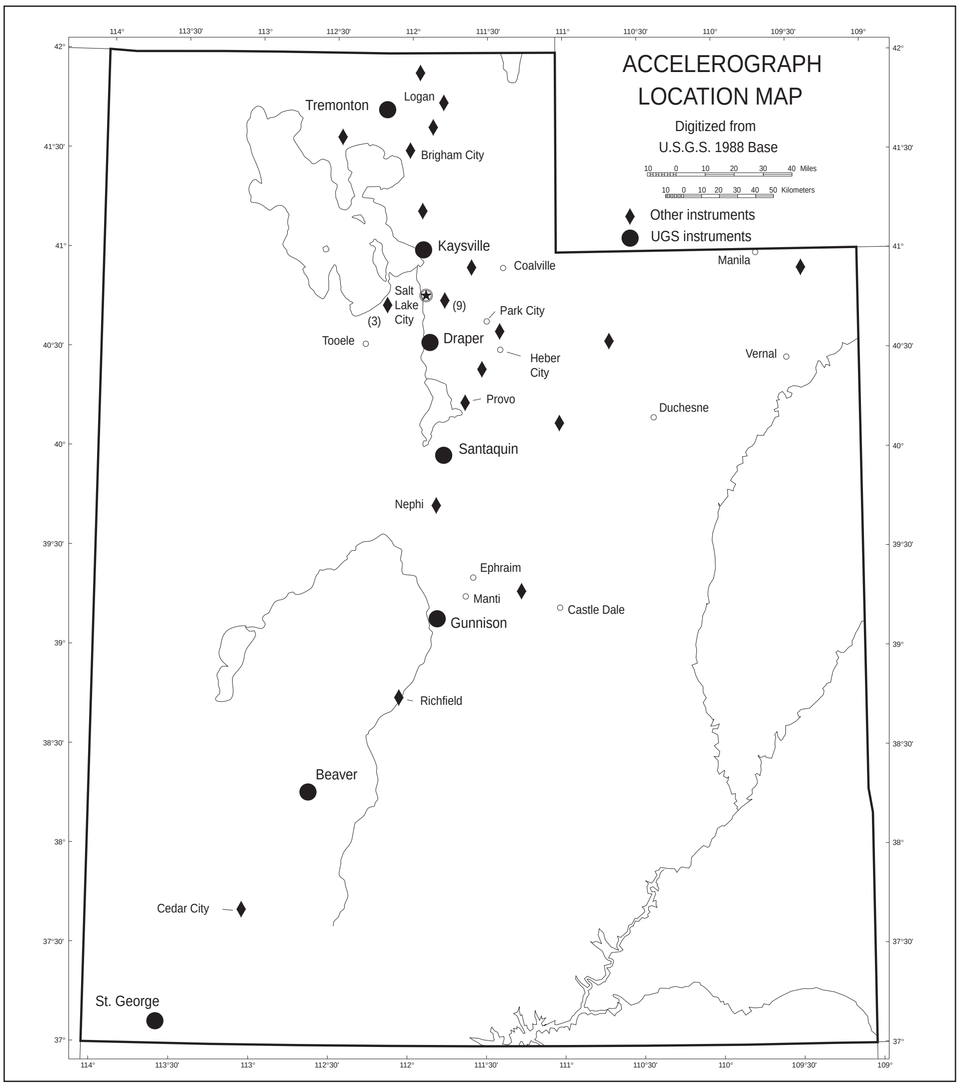
Please consider donating to the UGS Sample Library Trust Fund, to help ensure that important geologic samples continue to be available to geologists, students, and researchers for a very long time. For additional information on the Sample Library, or the Sample Library Trust Fund, please contact Kimm Harty or Bryce Tripp at (801) 537-3300.

New Strong-Motion Instruments will monitor Earthquake Ground Shaking in Utah

by Francis X. Ashland

Earthquakes occur daily in Utah. Fortunately, most are too small to cause damaging ground shaking. However, we know that earthquakes large enough to cause damage occur every few years in Utah. Some large historical earthquakes, including the 1934 Hansel Valley and 1962 Cache Valley earthquakes, could have caused extensive damage, but luckily occurred in less densely populated areas of the state. The potential severity of damage in urban areas from strong ground shaking was illustrated in recent earthquakes in Kobe, Japan and Northridge, California. As Utah's population grows and the state becomes increasingly urbanized, the likelihood that earthquake ground shaking will cause damage also increases. What would be the severity of strong ground shaking and resulting damage if the Wasatch Front had an earthquake the magnitude of or even larger than the Kobe or Northridge quakes? The problem is that we are not sure.

Currently, the most strict seismic building requirements in Utah are in the Wasatch Front. This area is designated as seismic zone 3 in the Uniform Building Code (UBC). Other areas of the state where earthquakes are less likely than along the Wasatch Front have less strict seismic requirements. Engineers are required under the UBC to design buildings and structures based on the estimated severity of ground shaking for the designated seismic zone. In Utah, we lack records of strong earthquake ground shaking known as strong-motion records and, therefore, the ground-shaking hazard and resulting earthquake-resistant design are based primarily on strong-motion records from outside the state. If we could obtain strong-motion data in Utah, we could better evaluate earthquake-engineering practices in the state to ensure that buildings and structures are neither under-designed, posing a life-safety threat, nor over-designed, wasting precious resources. Another use of strong-motion instruments is for "real-time" monitoring of damaging ground motions. This involves setting up the instruments to automatically send records to a central location for evaluation following an earthquake to help quickly determine the expected level of damage and aid in dispatching emergency responders to the hardest hit areas.



Map showing locations of new UGS strong-motion instruments (accelerographs) and other federally or privately owned instruments. Some instruments are in buildings and on dams, and are not free-field.

Wood-framed, steel maintenance shed at the Gunnison Valley High School meets the criteria of a free-field site. The use of such free-field sites will allow ground motions to be characterized and related to significant geologic and seismologic factors.

The Utah Geological Survey (UGS) recently deployed seven digital Kinemetrics SSA-2 strong-motion instruments (accelerographs) to obtain strong-motion records in Utah. This deployment is part of an initial phase of the Utah Strong-Motion Instrumentation Program (USMIP), a cooperative program with the University of Utah Seismograph Stations. Instruments were installed by Walt Jungblut of the U.S. Geological Survey's National Strong-Motion Program (NSMP), with assistance from the UGS, in Tremonton, Kaysville, Draper, Santaquin, Gunnison, Beaver, and St. George. The UGS selected these sites to fill gaps between the few existing federally and privately owned instruments to establish a skeletal network of instruments along a roughly north-south corridor in the Intermountain seismic belt (ISB), a broad zone of seismic activity where most of the magnitude 5 and larger earthquakes have occurred. The ISB is also where many of the known active faults like the Wasatch fault are found and is one of the areas of highest earthquake risk in the conterminous United States. With this skeletal network, we should get at least one strong motion record for any magnitude 5.0 or greater earthquake in the ISB in Utah.

One goal of the USMIP is to characterize earthquake ground shaking and relate it to geologic and seismologic factors such as type and thickness of subsurface materials, distance to the earthquake source, and earthquake magnitude. To do this, each instrument is in a small building or shed that meets the criteria for a "free-field" site. To be a free-field site, the building size and shape must not significantly affect the ground shaking. These buildings generally have only one story and no basement, and are less than 2,000 square feet in area. An objective of the USMIP is to establish a statewide network of these free-field instruments.

Funding for the seven new instruments was made available by a 1992 appropriation to the UGS by the Utah Legislature to begin the USMIP. At that time, an advisory committee of engineers and scientists was formed to guide the program and a long-term strategic plan was developed. Unfortunately, funding was discontinued after only one year, thus idling deployment of future instruments and eliminating funding for on-going maintenance of these seven instruments. As a result, deployment of additional instruments is on hold until funds become available to reactivate the USMIP. In the absence of funding, the seven new instruments will be maintained and monitored twice a year by the NSMP at no cost as part of a cooperative agreement with the UGS.

At present, the number of free-field instruments, which includes about a dozen federally or privately owned instruments, fails to provide adequate coverage to meet the goals of the USMIP. In 1989, a blue-ribbon panel recommended deployment of at least 108 instruments to obtain sufficient strong-motion measurements. Although the UGS is committed to achieving this goal, completion of the USMIP will only be possible if additional on-going funding is found.

Completed installation of a Kinemetrics SSA-2 accelerograph. Box mounted on wall holds instrument battery to ensure operation if electric power is lost. Cable attached to battery box is attached to WWVB receiver that provides accurate timing for the instrument.

Walt Jungblut of th USGS NSMP checks input parameters of a newly installed strong-motion instrument (lower left corner of photograph).

Survey News

Radon Studies in Utah

by Barry J. Solomon

The Utah Geological Survey (UGS), in cooperation with the Utah Department of Environmental Quality, Division of Radiation Control, participated in the SIRG Program (State Indoor Radon Grants) from 1990 through 1996. The UGS role is to assess the radon-hazard potential of the state and identify areas that have geologic factors conducive to elevated indoor-radon levels. The results of this activity are published by the UGS.

The radon-hazard potential of Utah is assessed and mapped in UGS Map 149; at 1:100,000 scale, or 1" = 16 miles, the map gives a good overview of the geologic factors influencing radon distribution in the state. The map booklet discusses the contribution of geology to the indoor-radon hazard, and the map uses geologic factors to depict low, medium, and high radon-hazard-potential categories. Several areas of Utah are experiencing rapid growth and may be within the category of highest radon-hazard potential.

Circular 81 discusses the nature of the indoor-radon hazard, its relation to geology, and techniques for measurement of indoor-radon levels. The radon-related geology and radon-hazard potential of many of these areas are discussed and mapped in more detail in a series of additional publications. These areas (and their respective publications) are: (1) Sandy, Salt Lake County, and Provo, Utah County (SS 85); (2) southern St. George Basin, Washington County, and Ogden Valley, Weber County (SS 87); (3) central Sevier Valley, Sevier County (SS 89); (4) Tooele Valley, Tooele County, the lower Weber River area, Weber and Davis Counties, and southeastern Cache Valley, Cache County (SS 90); (5) western Salt Lake Valley, Salt Lake County (SS 91); and (6) the Beaver basin, Beaver County (release date is 1997). Brief, non-technical summaries of these detailed reports are available free as PI-18, 21, 35-36, and 43-47. Each of these Public Information flyers includes a radon-hazard-potential map and responses to several of the most commonly asked radon-related questions.

These UGS radon-related publications provide a thorough overview of the indoor-radon hazard in Utah. They establish the geologic basis for the hazard, map its distribution, and provide both technical and non-technical discussions of the hazard suitable to the widest variety of interested individuals. Hopefully, this comprehensive information will serve to effectively reduce the radon-hazard potential in Utah and to protect the health and safety of its citizens.

Rebecca Hylland has accepted a job with DOGM as a Reclamation Specialist II with the Abandoned Mines Program. We are truly excited for her new adventures and wish her the best of luck in the underground.

Kevin McClure is the new geotech in the Economic Section replacing **Kimberly Waite** who has accepted a position as economic geologist doing mineral resource evaluations in California. The work involves extensive field work. Kim has been with the Economic section for some time. Best of luck, and good camping! Kevin is a recent graduate of the University of Utah in Environmental Earth Sciences. He spent the summer of 1994 taking core samples for the Ferron Sandstone Project.

Carl Ege is the new part-time employee in the UGS Bookstore. He is originally from Beechgrove, Indiana and is presently attending the University of Utah double-majoring in Environmental Earth Sciences/Geology with a minor emphasis in Chemistry.

Funding was recently approved for UGS to receive two U.S. Geological Survey NEHRP grants beginning in 1997. One is to trench the West Cache fault zone along the west side of Cache Valley (Bill Black and Barry Solomon will head the project, see page 4), and the second is with Kyle Rollins at Brigham Young University (with Mike Hylland of UGS) to prepare site response maps for the Salt Lake Valley. The latter will depict the amplification of earthquake ground motions by site soils.

Seismic Hazards Summit for the Basin and Range province. Reno, NV, May 13, 14, 15, 1997. Call for papers with titles due 2/5, abstracts due 3/10, and papers due 6/30. Contact http://vishnu.glg.nau.edu/wsspc/brpshs.ntml or the Western States Seismic Policy Council at (415)974-6435.

The "Strategic plan for the U.S. Geological Survey, 1996 to 2005" is available on the internet and comment is invited. If the earth science community doesn't respond, then we'll live with the results. This is a starting point for dialogue, not the final. http://online.wr.usgs.gov/stratplan.

Geologic logs of water wells available on the Internet

The UGS and the Utah Division of Water Rights are engaged in a cooperative project to produce high-quality geologic logs of water wells in Utah. This will provide detailed analyses and geologic interpretations of water-well cuttings to improve the understanding of sediments and rocks penetrated by the wells. Completed logs can be viewed and downloaded via the Water Rights' homepage at http://nrwrtl.nr.state.ut.us. Log onto the site and scroll to "Learn about water well drilling" in the section "Water Well Logs" and click on the highlighted text. Next, click the highlighted text of "Water well log demonstration project!!!" to see the available logs, listed by location. For further information, contact Mike Lowe (UGS) at (801) 537-3389.

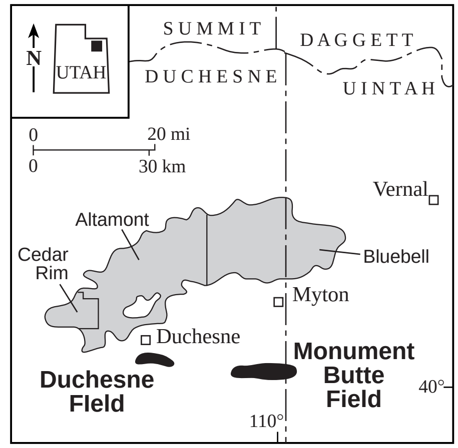
Energy News

The Utah Geological Survey (UGS) is working under a subcontract to TerraTek, Inc., Salt Lake City, on a study entitled Advanced Fracture Modeling in the Uinta Basin (Utah) for Optimized Primary and Secondary Recovery. The objective of the study is to better understand how natural fractures in reservoir rock affect the flow of hydrocarbons from the reservoir to the well bore. This knowledge can then be used to improve the way some oil wells are drilled and produced, resulting in increased oil production. Other participants in the study are the University of Utah, Reis and Associates, and the University of California, Berkeley. Equitable Resources Energy Company, Balcron Oil Division, is providing data to the study and will be coring and logging a new well in cooperation with the project. The study is funded by the U. S. Department of Energy (DOE).

The study area includes two fields, Duchesne and Monument Butte, in the southwest part of the Uinta Basin, south of the towns of Duchesne and Myton. In the Duchesne-Monument Butte area there are several east-west-trending normal faults collectively known as the Duchesne fault zone. Fracturing related to the fault zone is believed to affect oil production. Oil is produced in this area from reservoirs in the Green River Formation. The reservoirs are sandstone beds at a drill depth of 5,000 to 6,500 feet, that were deposited about 40 million years ago as river channels and beaches along the southern shore of ancient Lake Uinta.

Wells are drilled on 40-acre spacing (16 wells per square mile) in the Duchesne-Monument Butte area and often produce less than 100,000 barrels of oil per well. Most wells result in very small to no profit because of the low volume of oil produced. Recently, drilling activity in the Monument Butte area has increased significantly thanks to a DOE-funded study of a water flood in a portion of the Monument Butte Field conducted by Lomax Exploration Company (now Inland Resources, Inc.) and the University of Utah. Water flooding is a secondary oil-recovery technique in which water is pumped into some wells, increasing the pressure in the reservoir and pushing the oil towards the producing wells. This technique has been highly successful in the Monument Butte area, resulting in an estimated two-fold increase in the amount of oil per well that will ultimately be produced.

Balcron Oil Division recently formed the Humpback Water-flood Unit in the Monument Butte area. The Humpback Unit currently consists of 17 producing wells, some of which will be converted to water-injection wells in the near future. This summer Balcron Oil plans to drill, core, and log a new well in the Humpback Unit and contribute the data to the



TerraTek-led study. The UGS is gathering and mapping subsurface well data throughout the Duchesne-Monument Butte area for the study. The data and resulting geologic interpretations by the UGS, along with the new data provided by Balcron Oil, will be used by the other participants to develop computer models of the oil reservoir. The models will be used to run various oil-flow simulations to determine how the hydrocarbons move through the reservoir. Any number of fractures at different orientations can be introduced into the computer model. Oil flow through the fractured reservoir rock is then simulated, allowing engineers and geologists to better understand how oil moves through the actual reservoir. This knowledge can be used to improve the primary production and water-flood operations, resulting in even more oil ultimately recovered.

The Utah Seismic Safety Commission (USSC) has published a report compiled by Bruce Funk entitled *Earthquake Safety in Utah-A Progress Report on Activities for the Period July 1994 - June 1996*. It briefly assesses the status of the USSC's plan, *A Strategic Plan for Earthquake Safety in Utah,* distributed to legislators, local governments, and others in 1995. The progress report is on activities during the past two years that have addressed earthquake safety. Specifically, the report draws data from a survey of state and local government agencies, professional societies, businesses, hospitals, school districts, emergency planners, counties, cities, and the media in 1996 (two mailings). Respondents were asked to report actions taken between July 1, 1994 and June 30, 1996 in five areas of earthquake safety. Each area corresponded to one of the major objectives of the *Strategic Plan.*

Earthquake Safety in Utah is available free from the Natural Resources Bookstore on the first floor at 1594 West North Temple, in Salt Lake City, or contact Janine Jarva at the Utah Geological Survey, (801) 537-3386, e-mail: jjarva@state.ut.us, or Brenda Edwards at Utah Division of Comprehensive Emergency Management, (801) 538-3752, e-mail: pscem.bedwards@state.ut.us.

"Glad You Asked"

by Rebecca Hylland

Landslide Evaluation Issues - Examples From Timber Lakes Estates

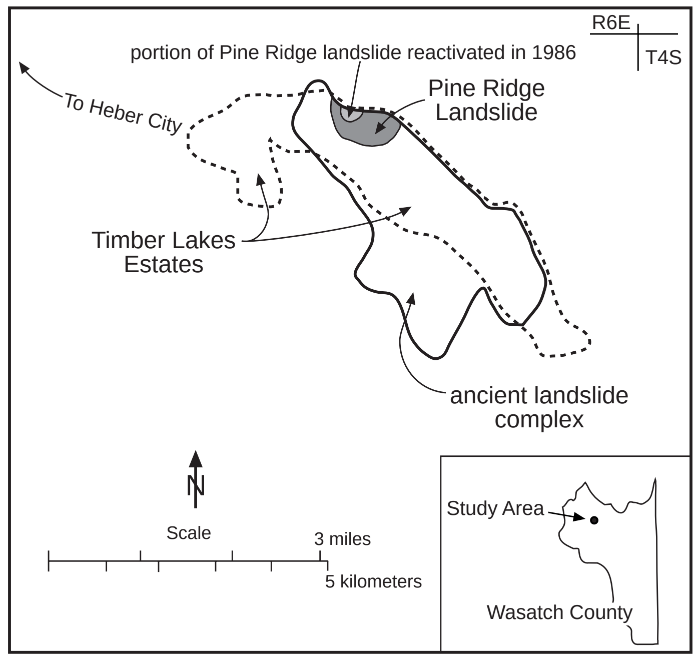
A landslide devil seems to laugh at human incompetence.
-Anonymous Japanese Engineer

Landslides. We hear about them through the media as they occur in other parts of the world, but are landslides a concern for those living in Utah? Yes!

Steep slopes, mountainous terrain, certain rock types, and narrow debris-choked canyons make Utah subject to certain landslide hazards. In fact, landslides have caused significant economic loss in Utah. They have damaged or destroyed buildings, roadways, and railroads; blocked rivers causing destructive flooding, and resulted in the loss of life. Utah ranked third in the United States in terms of largest total landslide damage and cost per capita in the decade spanning 1973 through 1983. Contributing to losses sustained in Utah during this period was the 1983 Thistle landslide in Spanish Fork Canyon, Utah County—the most expensive landslide to date (approximately $337 million in 1983 dollars) in U.S. history. The U.S. Geological Survey assigns Utah a landslide-hazard rating of "severe," the highest of five landslide-hazard classes. Although increased availability of landslide-hazard maps has enabled consultants, local governments, and the public to become more aware of Utah's landslide hazard, exposure to this hazard has risen, mainly due to the increased population and continued development on landslide-prone slopes.

Landslide-hazard evaluation is a complex task. Much of the difficulty lies in predicting if and when future movement on a formerly active landslide will occur. The geologist or engineer has to evaluate the interactions among rock and soil characteristics, slope steepness, groundwater conditions, and proposed development plans. Because of changes in site conditions, development on landslides can decrease slope stability and promote further landsliding.

Timber Lakes Estates located east of Heber City in Wasatch County, Utah is a community used here to illustrate the difficulties geologists and engineers face in evaluating the landslide hazard, and the development-related issues faced by property owners and local governments.

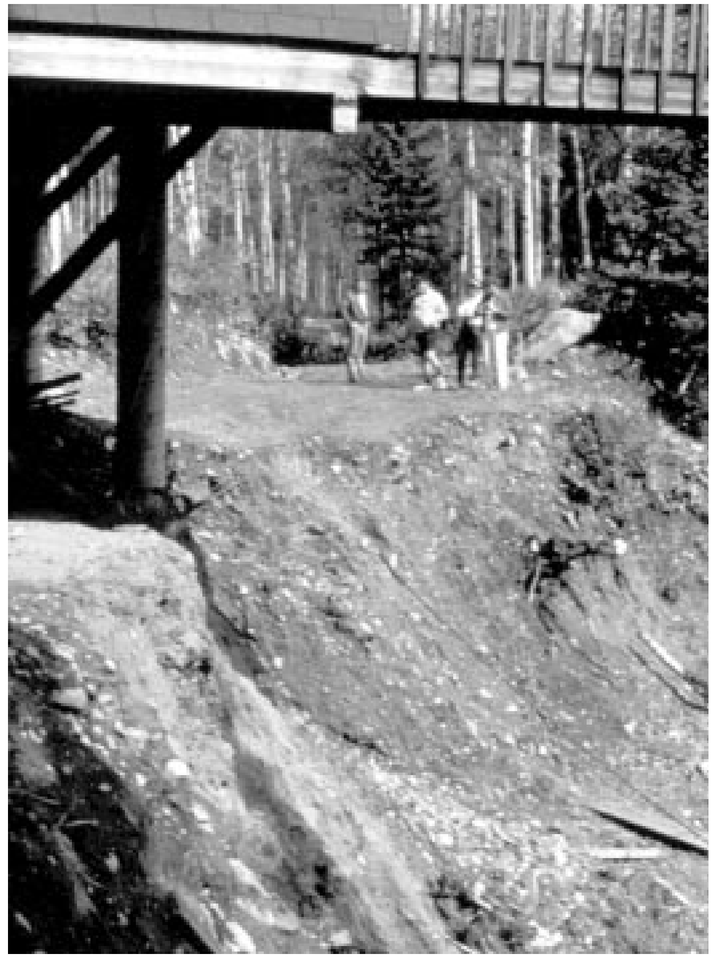


Location of Timber Lake Estates, ancient landslide complex, and Pine Ridge landslide.

To aid in land-use planning, Wasatch County asked the Utah Geological Survey (UGS) to produce geologic-hazards maps for the western part of the county. When development is planned within a geologic-hazard area, the county may, depending on the level of the hazard and nature of the proposed development, require the developer to complete a more detailed geotechnical study of the site. This allows any needed hazard-reduction measures to be included in the development plans prior to construction. Timber Lakes was platted in the early 1970s before the county knew of the landslide hazard. Much of Timber Lakes is situated on ancient landslide deposits, parts of which were reactivated during the wet years of the mid-1980s. At the request of Wasatch County, the UGS is currently investigating an area known as the Pine Ridge landslide (a smaller slide within the larger area of ancient landslide deposits). More than 100 lots have been platted on and adjacent to this slide. The Pine Ridge landslide is inactive except for an 80-acre section that reactivated in 1986. This reactivated area affected only one developed lot but, with continued development, the slide may impact more, through development-related slide movement. Most of Timber Lakes was platted and the lots were sold prior to any geologic-hazard studies. Because of this, the developer is no longer responsible for having the landslides studied, and the responsibility now lies with individual lot owners.

All property owners (including those at Timber Lakes) should know that inclusion of a lot within a mapped geologic-hazard area does not necessarily render the property valueless or unbuildable; it simply means that the hazard should be addressed prior to development. A site-specific geotechnical study benefits lot owners by making them aware of the hazard, and allows them to incorporate any recommended hazard-reduction measures into the location and design of their structures. However, a drawback to conducting a geotechnical study of a single lot on a large landslide is that the study is specific to the conditions of that particular lot and cannot adequately address the stability of the larger slide as a whole. The cumulative effects of development activities (such as landscape irrigation, cuts into slopes for foundations and driveways, and drain fields) on all the lots on and adjacent to the landslide are not taken into consideration in lot-specific studies. Area-wide geotechnical studies of large landslides and the incorporation of geotechnical recommendations into lot development can be expensive. However, the costs to individual lot owners can be reduced through cooperative funding. Also, the money spent up front in hazard reduction is nothing compared to the cost of rebuilding. Remember, landslide damage is not covered by homeowner's insurance.

One issue that has arisen at Timber Lakes is the concept of acceptable risk. For example, some lot owners are willing to build their houses on landslides for which a geotechnical study to determine the stability of the landslide has not been made. However, issuing a building permit to a risk-taking lot owner could indirectly force others to also accept greater risk and potential liability as is illustrated in the following example: Suppose the risk-taker installs a septic-tank system that provides sufficient water to the subsurface to reactivate the landslide, which undercuts the foundation of a neighbor's house not on, but just downslope from the slide. In this scenario, the risk-taker's actions result not only in the destruction of a neighbor's house, but also in high costs associated with emergency response, remediation, and, most likely, lawsuits. The neighbor whose house was destroyed will not be pleased with the county that issued the building permit to the risk-taker. However, the governmental-immunity law prohibits lawsuits against local county governments. This



Property damaged during landsliding in 1986 at Timber Lakes Estates, Wasatch County (photo by UGS staff).

scenario shows how the acceptable-risk issue is often more complex than it may seem initially.

Another issue that potential landowners at Timber Lakes (and elsewhere in Utah) face is that disclosure of geologic hazards is not a legal requirement in this state. This means that the real estate agent or property seller does not have to tell you that the land for sale has geologic hazards associated with it. So potential buyers beware.

Listed below are some steps the future landowner can take to obtain information on the property of interest before buying:

1) Visit the property. Ask the local government's planning department for information on setbacks from steep slopes. Take the information to the property of interest and walk it. Some general items to look for are: benched topography, naturally ponded water near the top of benched areas, and seeps near the base of steep slopes. Remember the setback information the county gave you and measure it on your property. You want room for needed buildings and drain fields for septic systems beyond the building setback.

2) Hire a consultant. If you suspect that the property

Continued on page 13 . . .

New Publications of the UGS

The Wasatch fault, by S.N. Eldredge, 12/96, 17 p. (color brochure) PI-40 . . . . **$2.00**

Written for the non-geologist, profusely illustrated, and readily understandable. What is it, where is it, how to recognize it, building on it, what are earthquakes and how often do they occur, the future of the fault, and where to get more information - these are all included in this informative brochure.

Radon-hazard potential of western Salt Lake Valley, Salt Lake County, Utah, by B.D. Black, 27 p., 1 pl., 1:50,000, 1996, SS-91 . . . . **$6.00**

The area between the Jordan River and the eastern foothills of the Oquirrh Mountains shows increased potential for high radon levels on the western side, decreasing to the east. Factors affecting this higher potential include the presence of uranium-enriched geologic material, soils of moderate permeability, and deep ground water.

Paleoseismology of Utah Volume 7: Paleoseismic investigation on the Salt Lake City segment of the Wasatch fault zone at the South Fork Dry Creek and Dry Gulch sites, Salt Lake County, Utah, by B.D. Black, W.R. Lund, D.P. Schwartz, H.E. Gill, and B.H. Mayes, 22 p., 1 pl., 1996, SS92 . . . . **$5.25**

The two trench sites are in the southeastern part of the Salt Lake Valley and provide the only location on the heavily urbanized segment of this segment of the WFZ where it is possible to develop a complete surface-faulting chronology for the past 6,000 years. New information presented shows an earthquake hazard greater than previously assumed.

Interim geologic map of the Kelton Pass quadrangle, Box Elder County, Utah and Cassia County, Idaho, by M.L. Wells, 70 p., 3 pl, 1:24,000 and 1:48,000, 12/96 OFR-342 . . . . **$8.85**

Interim geologic map of the Santa Clara quadrangle, Washington County, Utah, by G.C. Willis and J.M. Higgins, 87 p., 2 pl., 1:24,000, 12/96 OFR-339 . . . . . . **$9.65**

Recent publications relating to radon *(see the program summary on p. 9)* ***are:***

Radon-hazard-potential areas in Sandy, Salt Lake County, and Provo, 1994, SS-85 . . . . **$6.00**

Radon-hazard potential of the southern St. George basin, and Ogden Valley, 1995, SS-87 . . . . **$5.95**

Radon-hazard potential of the central Sevier Valley, 1996, SS-89 . . . . **$5.50**

Radon hazards in Utah, 1990, C-81 . . . . **$3.50**

Radon-hazard potential of western Salt Lake Valley, 1996, SS-91 . . . . **$6.00**

Radon-hazard potential of the lower Weber River area, and southeastern Cache Valley, 1996, SS-90 . . . . **$6.00**

The radon-hazard-potential map of Utah, 1993, M-149 . . . . **$3.50**

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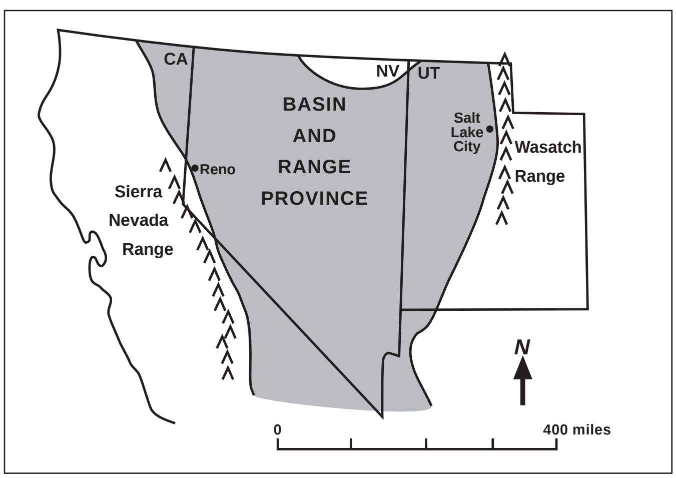
Teacher's Corner

By Sandy Eldredge

How many inches per year do Salt Lake City, Utah and Reno, Nevada move away from each other?

You may not realize that 15 million years ago, if roads existed, you could have driven from Salt Lake City, Utah to Reno, Nevada in 4 hours instead of 6 hours. OK, I understand that this tidbit of information is not on everyone's mind, but you can have fun using math as you geologically sleuth your way to the answer.

First, pull out a relief map that covers Utah, Nevada, and California. You can see that Salt Lake City (and the adjacent Wasatch Range) and Reno (and the adjacent Sierra Nevada Range in California) border an area of the United States where the landscape is dominated by north-south-trending mountain ranges and alternating valleys (basins).



Not surprisingly, this area is called the Basin and Range Physiographic Province. The ranges and basins have been forming for the past 10 to 20 million years in response to east-west stretching of the earth's crust. Stretching creates tension that is released by slow continuous movement or sudden movement along a fault (a break in the earth's crust), which causes earthquakes. During an earthquake, the mountains rise while the valleys drop along the faults. The stretching continues today.

Now back to the original question. The map shows the locations of Salt Lake City and Reno. The cities are 400 miles apart, yet 15 million years ago they were only 250 miles apart. How many inches per year do the two cities move away from each other?

Answer

- Total movement is 150 miles in 15,000,000 years
- 5,280 feet = 1 mile
- 5,280 x 150 miles = 792,000 feet
- Distance moved in 15,000,000 years is 792,000 feet
- 792,000 feet / 15,000,000 years = 0.0528 feet / one year
- 1 foot = 12 inches
- 12 x .0528 feet = 0.6336 inches
- The two cities are moving apart at a rate of 0.6 inches (or about 1/2 inch) per year.

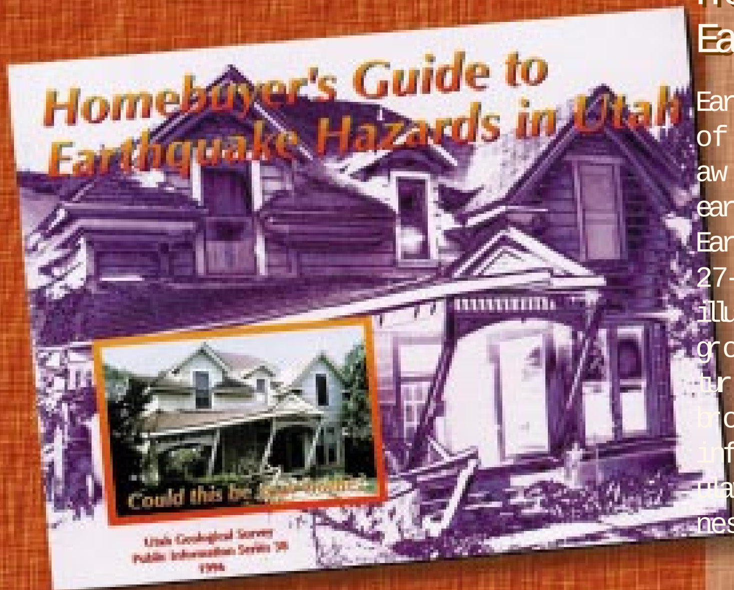
Visit ourTeacher's Corner web page at http://utstdp-www.state.ut.us/~ugs/tcorner.htm

Continued from page 11 . . .

may have a landslide hazard (or if the county or city requires a study), contact an engineering geologist or geotechnical engineer and have them assess the property. The consultant can also provide you with recommendations on what can be done during the development of your lot to reduce the landslide risk.

3) Consult geologic-hazard maps. Landslide-hazard maps (1:24,000 scale) are available for most Wasatch Front counties as well as other areas in Utah; check with your county planning department. Available at the UGS are landslide compilation maps for the entire state at 1:100,000 scale. Remember that 1:100,000 and 1:24,000 scale maps do not show enough detail for lot-specific purposes. Their intended use is for regional planning. These maps should be used only to see if you may be on or near a known landslide-hazard area.

4) Research as much geologic information as possible. The UGS is a resource for information on geologic units that are susceptible to landsliding. Also, the UGS has recently released a publication titled "Guidelines for Evaluating Landslide Hazards in Utah," Circular 92, which is an aid to geologists and engineers for evaluating landslides in this state.



Homebuyer's Guide to Earthquake Hazards in Utah

Earthquakes pose a risk to the majority of Utahns and it is important to be aware of the multi-hazard effects of an earthquake. The Homebuyer's Guide to Earthquake Hazards in Utah is a colorful, 27-page brochure that describes and illustrates in easy terms the hazards of ground shaking, liquefaction, fault rupture, slope failures, and flooding. The brochure leads the reader to additional information sources on hazards in particular areas and about personal preparedness. This is a good introduction to help

The Wasatch Fault

The Wasatch fault is one of the longest and most active faults of its type in the world, and contributes to the Wasatch Front's designation as having the greatest earthquake risk in the interior of the western United States. Pick up this colorful, photo-packed brochure that tells what the fault is, where it is, how to recognize it, land uses (good and bad) on it, how often earth-

Use the order form on page 12.

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